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Methylviologen-mediated electrochemical synthesis of platinum nanoparticles in solution bulk

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Abstract

© 2017, Pleiades Publishing, Ltd.Platinum nanoparticles (PtNPs) are synthesized by methylviologen-mediated reduction of PtCl2 at the potentials of the MV2+/MV•+ redox couple in 40% aqueous DMF solution. In the absence of stabilizing agents and in the presence of a stabilizer in the form of spherical silica NPs or alkylamine-modified silica NPs (SiO2-NHR), a part of PtNPs (14–18%) are deposited on the electrode while the rest of particles remain in solution to form coarse aggregates which precipitate. In the latter case, PtNPs are also partly bound to form individual ultrafine NPs (3 ± 2 nm) on the SiO2-NHR surface. In the presence of polyvinylpyrrolidone (PVP), the generated PtNPs (18 ± 9 nm) neither aggregate nor deposit on the cathode but are completely stabilized in solution being encapsulated within the PVP matrix. The obtained PtNPs are characterized by the methods of dynamic light-scattering and electron microscopy.

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Keywords

electrosynthesis, mediator, methylviologen, nanoparticles, platinum, polyvinylpyrrolidone, silica nanoparticles

References

[1] Pomogailo, A.D., Rozenberg, A.S., and Uflyand, I.E., Nanochastitsy metallov v polimerakh (Metal Nanoparticles in Polymers), Moscow: Khimiya, 2000.

[2] Roldugin, V.I., Russ. Chem. Rev., 2000, vol. 69, p. 821.

[3] Daniel, M.C. and Astruc, D., Chem. Rev., 2004, vol. 104, p. 293.

[4] Suzdalev, I.P., Nanotekhnologiya: Fiziko-khimiya nanoklasterov, nanostruktur i nanomaterialov (Nanotechnology: Physical Chemistry of Nanoclusters, Nanostructures, and Nanomaterials), Moscow: Librokom, 2009, 2nd Ed.

[5] Volkov, V.V., Kravchenko, T.A., and Roldugin, V.I., Russ. Chem. Rev., 2013, vol. 82, p. 465.

[6] Dykman, L.A., Bogatyrev, V.A., Shchegolev, S.Yu., and Khlebtsov, N.G., in Zolotye nanochastitsy. Sintez, svoistva, biomeditsinskoe primenenie (Gold Nanoparticles: Synthesis, Properties, and Biomedicinal Application), Moscow: Nauka, 2008.

[7] Handbook of Less-Common Nanostructures, Kharisov, B.I., Kharissova, O.V., and Ortiz-Méndez, U., Eds., Boca Raton: CRC, 2012.

[8] Faraday, M., Philos. Trans. Roy. Soc. London, 1857, vol. 147, p. 145.

[9] Egorova, E.M., Nanotekhnika, 2004, p. 15.

[10] Egorova, E.M., Russ. J. Phys. Chem. A, 2010, vol. 84, p. 629.

[11] Petrii, O.A., Russ. Chem. Rev., 2015, vol. 84, p. 159.

[12] Haber, F., Z. Anorg. Chem., 1898, vol. 16, p. 438.

[13] Rodrigues-Sanchez, L., Blanko, M.L., and Lopez-Quintela, M.A., J. Phys. Chem. B, 2000, vol. 104, p. 9683.

[14] Yin, B., Ma, H., Wang, S., and Chen, S., J. Phys. Chem. B, 2003, vol. 107, p. 8898.

[15] Saez, V. and Mason, T.J., Molecules, 2009, vol. 14, p. 4284.

[16] Zhu, J., Liu, S., Palchik, O., Koltypin, Y., and Gedanken, A., Langmuir, 2000, vol. 16, p. 6396.

[17] Reisse, J., Caulier, T., Deckerkheer, C., Fabre, O., Vandercammen, J., Delplancke, J.L., and Winand, R., Ultrason. Sonochem., 1996, vol. 3, p. 147.

[18] Reetz, M.T. and Helbig, W., J. Am. Chem. Soc., 1994, vol. 116, p. 7401.

[19] Becker, J.A., Schäfer, R., Festag, R., Ruland, W., Wendorff, J.H., Pebler, J., Quaiser, S.A., Helbig, W., and Reetz, M.T., J. Chem. Phys., 1995, vol. 103, p. 2520.

[20] Reetz, M.T., Quaiser, S.A., and Merk, C., Chem. Ber., 1996, vol. 129, p. 741.

[21] Reetz, MT., Helbig, W., Quaiser, S.A., Stimming, U., Breuer, N., and Vogel, R., Science, 1995, vol. 267, p. 367.

[22] Reetz, M.T., Winter, M., Breinbauer, R., Thurn-Albrecht, T., and Vogel, W., Chem.-Eur. J., 2001, vol. 7, p. 1084.

[23] Yanilkin, V.V., Nasybullina, G.R., Ziganshina, A.Yu., Nizamiev, I.R., Kadirov, M.K., Korshin, D.E., and Konovalov, A.I. Mendeleev Commun., 2014, vol. 24, p. 108.

[24] Yanilkin, V.V., Nasybullina, G.R., Sultanova, E.D., Ziganshina, A.Yu., and Konovalov, A.I., Russ. Chem. Bull., 2014, vol. 63, no. 6, p. 1409.

[25] Yanilkin, V.V., Nastapova, N.V., Nasretdinova, G.R., Mukhitova, R.K., Ziganshina, A.Yu., Nizameev, I.R., and Kadirov, M.K., Russ. J. Electrochem., 2015, vol. 51, p. 951.

[26] Fedorenko, S., Jilkin, M., Nastapova, N., Yanilkin, V., Bochkova, O., Buriliov, V., Nizameev, I., Nasretdinova, G., Kadirov, M., Mustafina, A., and Budnikova, Y., Colloids Surf., A, 2015, vol. 486, p. 185.

[27] Yanilkin, V.V., Nastapova, N.V., Sultanova, E.D., Nasretdinova, G.R., Mukhitova, R.K., Ziganshina, A.Yu., Nizameev, I.R., and Kadirov, M.K., Russ. Chem. Bull., 2016, vol. 65, p. 125.

[28] Nasretdinova, G.R., Osin, Y.N., Gubaidullin, A.T., and Yanilkin, V.V., J. Electrochem. Soc., 2016, vol. 163, p. G99.

[29] Nasretdinova, G.R., Fazleeva, R.R., Mukhitova, R.K., Nizameev, I.R., Kadirov, M.K., Ziganshina, A.Yu., and Yanilkin, V.V., Electrochem. Commun., 2015, vol. 50, p. 69.

[30] Nasretdinova, G.R., Fazleeva, R.R., Mukhitova, R.K., Nizameev, I.R., Kadirov, M.K., Ziganshina, A.Yu., and Yanilkin, V.V., Russ. J. Electrochem., 2015, vol. 51, p. 1029.

[31] Yanilkin, V.V., Nastapova, N.V., Nasretdinova, G.R., Fazleeva, R.R., and Osin, Y.N., Electrochem. Commun., 2015, vol. 59, p. 60.

[32] Nasretdinova, G.R., Fazleeva, R.R., Osin, Y.N., Gubaydullin, A.T., and Yanilkin, V.V., Russ. J. Electrochem., 2017, vol. 53.

[33] Yanilkin, V.V., Nasretdinova, G.R., Osin, Y.N., and Salnikov, V.V., Electrochim. Acta, 2015, vol. 168, p. 82.

[34] Yanilkin, V.V., Nastapova, N.V., Nasretdinova, G.R., Fedorenko, S.V., Jilkin, M., Mustafina, A.R., Gubaidullin, A.T., and Osin, Y.N., RSC Adv., 2016, vol. 6, p. 1851.

[35] Yanilkin, V.V., Nastapova, N.V., Nasretdinova, G.R., Fazleeva, R.R., and Osin, Y.N., Electrochem. Commun., 2016, vol. 69, p. 36.

[36] Leontyev, I., Kuriganova, A., Kudryavtsev, Y., Dkhil, B., and Smirnova, N., Appl. Catal., A, 2012, vol. 431–432, p. 120.

[37] Weitz, E., Angew. Chem., 1954, vol. 66, p. 658.